The range, abundance and habitat of Hinde's Babbler *Turdoides hindei*: fine-scale changes in abundance during 2000–2011 reflect temporal variation in scrub cover

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Summary

In developing countries 'land sparing' may be more effective than 'land sharing' in partially mitigating the impacts of farming on bird species diversity. We examined the pattern of change in the global and local distribution of Hinde's Babbler *Turdoides hindei*, a 'Vulnerable' Kenyan endemic whose local abundance is dependent on a passive form of land sharing, in which farmland is left fallow or abandoned, enabling *Lantana* scrub to colonise. In 2011 we assessed the species' global range and resurveyed three IBAs, surveyed previously in 2000–01, to determine whether fine-scale changes in abundance reflected temporal changes in habitat quality. Although the babbler's known range increased between 1900–70 and 1991–2011, we suggest that this apparent expansion largely reflects an improved knowledge base, and that several recently discovered sites are likely to have been overlooked in the past. In combination, the three IBAs surveyed in 2000-01 and 2011 showed little net change in the number of individuals (+1.3%) or groups (-3.8%) encountered, despite a 68% decline in the number individuals recorded at one site. Within 1-km transect sections there was a positive correlation between change in Hinde's Babbler abundance and change in the amount of scrub cover available, such that a reduction in scrub cover of 22 and 6 percentage points, respectively, was associated with the loss of one group or one individual. The availability of scrub cover was dependent mainly on the amount land left uncultivated, perhaps in response to changes in the value of coffee and other crops. Since the babbler's abundance thus currently depends mainly on land sharing by default, rather than by design, we suggest that a more proactive approach, involving land purchase or payments for land set aside, might help to secure its future.

Introduction

Farming, including the conversion of land to farmland and its intensifying use, is the single biggest threat to Red Listed bird species, accounting for 37% of threats, and is more important for species in developing countries than in developed countries, accounting for 40% and 24% of threats, respectively (Green *et al.*

2005). Hinde's Babbler *Turdoides hindei*, a 'Vulnerable' Kenyan endemic, is one such species, being associated mainly with residual patches of scrub and riverine thickets, interspersed with food crops, coffee plantations and pasture (Njoroge *et al.* 1998, Stattersfield *et al.* 1998, BirdLife International 2012). Despite the ubiquity of these broad habitat features the species is restricted mainly to the moist, southern slopes of Mt Kenya and the foothills of the Aberdares, with small, outlying populations in the catchments of the Tana and Athi Rivers (Njoroge & Bennun 2000, Shaw *et al.* 2003). First described by Sharpe (1900), its range was thought to have contracted substantially by the 1970s (Plumb 1979), apparently as a result of scrub clearance, perhaps compounded by human disturbance and hunting (Njoroge *et al.* 1998, Njoroge & Bennun 2000). By 1980–2001 its Area of Occupancy had fallen by 30%, and in 2000-01 its global population was estimated at 1,500–5,600 birds (Shaw *et al.* 2003).

During 1994 and 2000–01 surveys were conducted at six Hinde's Babbler sites, to estimate population sizes and to investigate the relationship between scrub cover, babbler density and breeding success (Njoroge & Bennun 2000, Shaw & Musina 2003, Shaw *et al.* 2003). Relatively high densities of Hinde's Babbler were recorded at two intensively cultivated, high-rainfall sites that had retained small amounts of scrub cover, mainly of the exotic *Lantana camara* (Njoroge *et al.* 1998, Shaw & Musina 2003). The distribution of babbler groups on these two sites showed a positive, non-linear relationship with scrub cover, levelling out where cover exceeded 15–20% (Shaw & Musina 2003). Breeding success (the proportion of young birds present) also varied in relation to the amount of scrub available, being significantly higher within areas retaining at least 10% cover (Shaw & Musina 2003). In contrast, babbler densities were much lower on less cultivated, semi-arid sites, despite these having retained larger amounts of scrub. Overall, the bulk of the species' global population appeared to lie within fertile, intensively farmed areas that support high human population densities, and consequently offer limited scope for conservation through statutory site protection (Shaw & Musina 2003).

In North America and, particularly, in Europe, the negative impacts of farming on biodiversity have been mitigated partially through 'land sharing': the adoption of wildlife-friendly farming techniques, including the retention of extensively farmed semi-natural habitats (Pain & Pienkowski 1997, Krebs *et al.* 1999, Donald *et al.* 2001). Since wildlife-friendly practices often require the landowner to forego opportunities for higher crop yields, such schemes can usually be sustained only through the payment of financial compensation. A second approach, 'land-sparing', involves attempting to maximise yields on existing farmland, while setting aside areas of land that support intact, natural habitats, or on which natural habitats may be restored (Balmford *et al.* 2005, Green *et al.* 2005).

Examples of land sparing in the tropics (e.g. Phalan *et al.* 2011, Chandler *et al.* 2013, Hulme *et al.* 2013), and models comparing the likely benefits of land sparing versus land sharing worldwide (Green *et al.* 2005, Perfecto & Vandermeer 2008, Ewers *et al.* 2009), have contrasted the level of biodiversity sustained within a matrix of farmed and semi-natural habitats, with that sustained through sparing forest fragments. Empirical studies in southwest Ghana and northern India (Phalan *et al.* 2011) and southern Uganda (Hulme *et al.* 2013) have shown that fewer species benefit from low-yield farming coupled with land sharing, than from

high-yield farming, if the latter is used as part of a strategy to reduce forest loss. A broadly similar pattern has been reported from Costa Rica, where the richness and diversity of forest-dependent birds was higher in a land-sparing coffee system than on land-sharing farms with shade-tolerant coffee plantations (Chandler *et al.*, 2013).

Here we describe changes in the known range of Hinde's Babbler, its response to local changes in the distribution of scrub cover, and consider whether a more proactive approach is required, in which land sharing occurs more by design than by default. We determined changes in the status of Hinde's Babbler at two spatial scales: by measuring trends in the global distribution of Hinde's Babbler records during 1900–2011; and by assessing changes in the species' abundance and demography at three Important Bird Areas (IBAs), surveyed in 2000–01 and 2011. To determine the likely causes of any change in abundance we compared the distribution of scrub cover and of babbler groups within 1-km transect sections at each site. Specifically, we sought to determine the average change in scrub cover associated with an increase or a reduction in the number of Hinde's Babbler groups, adults and offspring.

Methods

Geographic range

We measured the distribution of Hinde's Babbler records during 1900–70, 1971–90 and 1991–2011, based on information presented in Plumb (1979), Lewis (1983, 1984), Collar & Stuart (1985), Lewis & Pomeroy (1989), Turner (1992), Shaw (1996), Bennun & Njoroge (1999), Burrell (1999), Mallalieu (1999), Maina & Eshiamwata (2000), Njoroge & Bennun (2000), Shaw *et al.* (2001, 2002) and Mulwa (2007). Recent records were also drawn from sightings submitted to Kenya Birds Net and the National Museums of Kenya, Nairobi. All records were aggregated into 10x10 km squares (hectads) on the UTM grid. Range size changes were quantified by counting the number of hectads within the species' Area of Occupancy (AoO: hectads known to be occupied) and Extent of Occurrence (EoO: the area bounded by occupied hectads) (Gaston 1991) in each period.

Abundance, demography and habitat

During 1–21 July 2011, Hinde's Babblers were surveyed at three sites previously surveyed in June-July 2000–01: at Mukurweini, Kianyaga and Machakos Valleys IBAs. Both surveys were timed to follow the long rains, and hence were likely to coincide with an annual peak in the number of recently fledged young, providing a measure of breeding success (Shaw *et al.* 2003). At each site a recording of Hinde's Babbler calls was played on a Roberts RC 9907 cassette player with a 2x1 W amplifier. The recording was played for 1–2 minutes at 50 m intervals along each of the watercourse transects surveyed in 2000–01, ensuring that each transect was sampled independently of variation in habitat quality. Observations were made between 07h00 and 19h00,

previous surveys having shown no significant diurnal variation in the ratio of survey effort to detection rate (Shaw *et al.* 2002). The size and age composition of each babbler group was recorded. Most groups were watched for a minimum of 10–15 minutes, allowing time for stragglers to arrive. Individuals were assigned to one of three age classes (adult, juvenile or fledgling) according to eye colour, gape and plumage, as described in Shaw and Musina (2003).

Habitat features were assessed by one observer (P.S.) at 250 m intervals along each transect. A Garmin 12 GPS was used to relocate habitat points surveyed in 2000–01. The median distance between each habitat point in 2011 and its nearest equivalent in 2000–01 was 11 m. At each point vegetation cover was estimated in four contiguous 50x50 m quadrats, in two pairs, on opposite banks of the watercourse. The following features were measured: altitude (to the nearest 20 m); topography (ridgetop, hillside, valley floor); slope (<30°; >30°); land use (uncultivated/semi-natural, part cultivated, intensively cultivated); presence/absence of food crop, coffee crop, banana crop; watercourse width category (<5 m; >5 m), whether dry or wet. Within each quadrat, tree cover (> 5 m high), scrub cover (< 5 m high) and coffee cover were estimated by eye, by pacing, or using a Leica LRF 800 Rangefinder. A total of 321 habitat points were surveyed.

To determine the relationship between habitat composition and the distribution of Hinde's Babbler groups, transects were divided into consecutive 1-km sections. Each habitat point and babbler group was assigned to its respective section, most sections encompassing four habitat points. Mean and modal values for each 1-km section were calculated for continuous and categorical habitat variables respectively, pooled from the 2000–01 and 2011 surveys. The presence/absence of Hinde's Babbler groups was treated as the dependent variable in a forward, stepwise logistic regression model, fitted using SPSS 19.0. Although the same 1-km sections from each survey were thus treated as independent samples, we feel that this treatment is justified, given the likely turnover in Hinde's Babbler numbers and habitat composition over the 10–11 yr interval between surveys. Variables were retained in the model if the probability associated with their alpha value was less than 0.10.

Results

Changes in geographic range

Since 1900, Hinde's Babbler has been recorded at sites spanning 650 m (Meru National Park) to 1,780 m a.s.l. (Mukurweini) in 53 10x10 km squares (hectads), indicating a global Area of Occupancy of c.5,300 km^2. A minimum convex polygon fitted around the 53 occupied hectads encompassed 227 hectads (Figure 1), indicating an Extent of Occurrence of c.22,700 km^2. Over the three time periods assessed (1900-70, 1971-90 and 1991-2011), the species' known range has varied markedly. Having been relatively widely distributed in 1900–70, its EoO had contracted sharply by 1971–90, giving rise to concerns of a substantial decline, both in global range and population size (Plumb 1979, Lewis 1983, 1984). During 1991–2011, however, its known range expanded, as a result of new discoveries at Meru NP and Ngaia Forest, the Muumoni Hills, Mukurweini,

and near to Wote, SE of Machakos. Conversely, no records were received from several outlying sites, at Athi River, Ruiru and Nziu River. As a result, the babbler's EoO and AoO have shown disparate trends (Figure 2), although both have increased since 1900-71; by 59% (EoO) and 182% (AoO). Note, however, that during 1991-2011 no records were received from 65% of hectads known to be occupied during 1971-90. Also, hectads known to be occupied during 1991–2011 represented just 58% of all hectads from which the species has been recorded.

Changes in abundance and demography

Surveys along 74 km of transects at Mukurweini, Kianyaga and Machakos Valleys IBAs in 2000–01 yielded a composite total of 304 Hinde's Babblers in 78 groups. In 2011, the same transects yielded 308 individuals in 75 groups, indicating little overall change in the number of individuals (+1.3%) or groups (-3.8%). There was, however, a marked change in the species' demography, with a 12% rise in the number of adults present (from 232 to 260) and a 30% reduction in the number of offspring (from 54 to 38).

These combined figures mask differing trends at the three sites (Table 1). At Mukurweini, the number of individuals detected had increased slightly (+2%), while the number of groups present had declined (-11%), as had the percentage of offspring in the population (from 19% to 16%). At Kianyaga, the number of individuals and groups recorded had risen; by 40% and 35%, respectively, while the percentage of offspring present had declined; from 17% to 7%. In contrast, the numbers of individuals and groups recorded at Machakos had fallen by 68% and 55%, respectively, since 2000–01. The percentage of young birds in the population had likewise declined; from 23% to 13% (Table 1).

Group size and age composition

Based on data pooled from the 2000–01 and 2011 surveys, Hinde's Babbler groups averaged 4.02 individuals (range 1–9; n = 211 groups), comprising a mean of 3.39 adults (mode: 3) and 0.63 juveniles or recent fledglings (mode: 0; n = 205 aged groups). Young birds accounted for 15.7% of all birds aged (n = 824) and were present in 42.9% of all groups fully aged during the two surveys. Collectively, breeding success at Mukurweini, Kianyaga and Machakos was slightly lower in 2011 than in 2000–01 (13.0% vs. 18.9% offspring; $\chi^2_1 = 0.816$; n.s.), although differences at each site were not statistically significant.

The percentage of groups containing at least one juvenile or recent fledgling varied in relation to the number of adults present. Young birds were present in 32.8% of 'small' groups (of 1–3 adults) compared with 59.5% of 'large' groups (4–8 adults; $\chi^2_1 = 14.165$; $P<0.001$). Similarly, small groups contained significantly fewer offspring per group than large groups (means: 0.45 vs. 0.92; Mann-Whitney U = 3453.0; $P<0.001$), and significantly fewer offspring per adult than large groups (means: 0.17 vs. 0.21; Mann-Whitney U = 4062.50; $P=0.027$).

Population change in relation to habitat change

The presence of Hinde's Babbler groups within 1-km transect sections at Mukurweini and Kianyaga was positively correlated with watercourse width category (Wald = 5.936, 1 d.f., P = 0.015). This feature is unlikely to influence abundance directly, however, and was also strongly related to scrub cover (Mann-Whitney U = 445.00; P < 0.001). When watercourse width was excluded from the model, Hinde's Babbler presence showed a positive correlation with scrub cover only (Wald = 3.971, 1 d.f., P = 0.046).

Change in percentage scrub cover within 1-km sections between 2000–01 and 2011 was positively related to the direction of change in the number of Hinde's Babblers detected (Figure 3). Sections in which Hinde's Babbler numbers had either increased or decreased showed a corresponding change in scrub cover, in the case of number of groups (Mann-Whitney U = 113.50; P = 0.002), adults (Mann-Whitney U = 167.00; P = 0.003) and offspring present (Mann-Whitney U = 63.00; P = 0.003). Changes in scrub cover were also correlated with the degree of change in the number of Hinde's Babbler groups and individuals encountered (Figure 4), although at a level only approaching statistical significance (Table 2). At Mukurweini and Kianyaga, the gain or loss of one group within a 1-km transect section was associated with a corresponding change in scrub cover of c.22 percentage points (P = 0.072). Similarly, the gain or loss of individual Hinde's Babbler adults or offspring was associated with a change in scrub cover of c.6 percentage points (P = 0.056) and c.19 percentage points (P = 0.082), respectively. A similar relationship was evident at Machakos, where changes in babbler numbers were associated with more substantial changes in scrub cover (Table 2).

Discussion

A marked reduction in the distribution of Hinde's Babbler sightings during the 1970s suggested that its global range had contracted, giving rise to concerns over its status. In addition, increasingly intensive cultivation within the babbler's known range, coupled with its evident dependence on scrub for cover and nesting, offered a plausible explanation for its decline (Plumb 1979, Njoroge *et al.* 1998). In contrast, we show that the known range of Hinde's Babbler has increased since 1900–70, perhaps as a result of improved data quality, and that its abundance increased at two key sites during 2001–2011, while declining markedly at a third.

Bigger range or better data?

Concerns over a decline in the global range of Hinde's Babbler stemmed mainly from the observation that sightings made during 1972–1979 were concentrated within a small part of its former range (Plumb 1979). This contraction was due largely to an absence of records from several outlying sites in the 1970s, including

Machakos, Athi River, Kitui and Nziu River. A polygon fitted around known sites from 1900–1971 indicated a global Extent of Occurrence of 17,500 km^2, whereas by 1979 it was considered to be 'fairly common' only within an area of 1,050 km^2 (Plumb 1979). Our findings show that the species' known EoO fell by 64% between 1900–1970 and 1971–90, but has since expanded markedly, due mainly to discoveries on the periphery of its known range. In contrast, its known AoO has risen progressively over the three time periods. Although both measures suggest that the global range of Hinde's Babbler expanded between 1900–70 and 1991–2011, this change could reflect an improved knowledge base rather than a genuine expansion, having coincided with a period in which observer mobility, communications (e.g. by e-mail), and the collation of species records have all improved markedly. Despite this, observer coverage throughout most of the species' range remains poor, as indicated by the disparity between its EoO and AoO, which differ by a factor of 4.3. Also, since *Turdoides* species tend to show limited dispersal (Gaston 1978a,b, Zahavi 1990, Monadjem *et al.* 1995, Raihani *et al.* 2010), Hinde's Babblers are unlikely to rapidly colonise new areas far from established populations. There is, therefore, a strong likelihood that sites newly discovered during 1991–2011, which include the largest known population (at Mukurweini), had been occupied hitherto, but overlooked.

Notwithstanding the recent additions to its known range, several aspects of the species' status give cause for concern. Despite an assumed improvement in observer coverage, Hinde's Babblers were recorded from just 31 hectads during 1991–2011, representing 58% of its historical AoO. Also, no records were received from 65% of the hectads occupied during 1971–90, most of them within intensively cultivated areas between Embu and Chuka, and between Sagana and Thika (Figure 1). The absence of recent records from at least some of these hectads is likely to represent a genuine decline.

Temporal variation in babbler abundance and scrub cover

Turdoides species in East Africa lay mainly during months of high rainfall, particularly in March-May (Shaw & Musina 2003). The two surveys, in June-July 2000-01 and 2011, were therefore timed to provide an indication of breeding success over the preceding wet season. Since rainfall level is likely to have a positive influence on breeding success, the prolonged drought that affected much of Kenya during 2008-2011 (PDNA 2012) may explain the decline in breeding success recorded at all three sites in 2011.

During 2000-2011 the number of Hinde's Babblers recorded at Machakos Valleys IBA declined by 68%. While low rainfall during 2008-11 may have contributed to this decline, the amount of scrub available at Machakos Valleys had also declined substantially; from 35% to 21% cover. Shaw and Musina (2003) demonstrated a positive spatial correlation between scrub cover and the presence and productivity of Hinde's Babbler groups, concluding that a relatively small change in the percentage of land retaining scrub cover is likely to have an appreciable impact on the number and breeding success of Hinde's Babblers.

During the 2011 survey signs of recent scrub clearance and regeneration were encountered often, particularly at Mukurweini, suggesting that there is a rapid turnover in the distribution of suitable habitat within Hinde's Babbler territories. Figures 3 and 4 illustrate the dynamic nature of the relationship between scrub presence and Hinde's Babbler abundance, and provide the first evidence of a temporal correlation between these two measures, at a scale close to that of individual babbler territories. While the direction of change in Hinde's Babbler numbers was strongly correlated with a change in mean scrub cover, the degree of change in babbler numbers was only weakly correlated with scrub cover change (Table 2), suggesting that the loss of one group was associated with a reduction in scrub cover of between 14 and 48 percentage points (mean±1SE).

Scrub retention through land sharing

While studies contrasting the potential benefits of land sharing and sparing in tropical farmland have focused on the greater species diversity associated with forest fragments (e.g. Phalan *et al.* 2011, Chandler *et al.* 2013, Hulme *et al.* 2013), Hinde's Babblers are strongly dependent on the persistence of scrub: a non-climax habitat whose distribution within the landscape is likely to change relatively rapidly. Currently, the species achieves its greatest densities where patches of scrub are set within a matrix of food crops and coffee plantations, as at Mukuweini and Kianyaga Valleys (Njoroge *et al.* 1998, Shaw *et al.* 2003). In 2000-01 and 2011 most of the scrub remaining at these sites consisted of small stands, typically of <0.05 ha, dominated by *Lantana camara*; an invasive, exotic shrub whose ability to rapidly colonise set-aside land may largely account for the babbler's persistence at these sites (Njoroge & Bennun 2000). That the babbler appears to benefit from the presence of *Lantana* is unusual, although not unique; elsewhere, bird species also reported to benefit include dispersing juvenile Australian Brush-turkeys *Alectura lathami* (Göth & Vogel 2003), Kirtland's Warblers *Dendroica kirtlandii* wintering in the Bahamas (Wunderle *et al.* 2010), Darwin's Finches *Geospiza* spp. in the Galapagos (Carrión-Tacuri *et al.* 2012) and four frugivores in South Africa (Mokotjomela *et al.* 2013). However, Hinde's Babbler is the only globally threatened bird species we are aware of whose local abundance is positively correlated with the shrub's distribution.

At Mukurweini, one small patch of land have been set aside deliberately to allow scrub to regenerate, for the benefit of Hinde's Babbler (C. Kabiru and C. Kariuki, pers. comm. 2011). Other than this, the scrub patches we surveyed will have arisen on land left fallow between crops, or abandoned, perhaps in response to variation in crop prices (particularly those of coffee). It therefore appears that the relatively high population densities of Hinde's Babbler sustained on these two IBAs has been achieved through land sharing; but by default rather than design. We suggest that a more proactive approach may be required to safeguard these populations in the long term. This might be achieved by adopting a model similar to that commonly used in Europe, in which farmers are paid to set aside land on which scrub is allowed to regenerate in rotation, particularly where few patches currently exist. Alternatively, the purchase of small land parcels by

conservation groups might provide greater long-term security, and a more flexible approach to their management.

In conclusion, a recent expansion in the known range of Hinde's Babbler is thought likely to reflect an improved knowledge base, rather than a genuine range extension. Conversely, further survey work is required to determine whether the species' apparent absence from hectads occupied prior to 1991 represents a genuine contraction, and to monitor any further changes in the small population remaining at Machakos Valleys IBA. Our findings help to quantify the local impact of scrub creation or removal on Hinde's Babbler abundance, and hence provide an indication of the potential value of small-scale set-aside within intensively cultivated areas. Further work is required to determine an optimum rotation length, patch size, distribution and species composition for the scrub cover on which Hinde's Babblers depend at these sites.

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Table 1. Changes in the number and demography of Hinde's Babbler groups at three IBAs between 2000–01 and 2011.

Site	Survey years	Groups	Birds	Density (birds km^{-1})	Mean group size	% offspring
Mukurweini	2000–01	44	174	5.82	3.95	18.6%
	2011	39	177	5.92	4.54	16.4%
	Change:	-11.4%	+1.8%	-	+14.8%	-
Kianyaga	2000–01	23	83	3.52	3.61	16.9%
	2011	31	116	4.92	3.74	6.6%
	Change:	+34.8%	+39.8%	-	+3.7%	-
Machakos	2000	11	47	2.28	4.27	23.4%
	2011	5	15	0.74	3.00	13.3%
	Change:	-54.5%	-68.1%	-	-29.8%	-

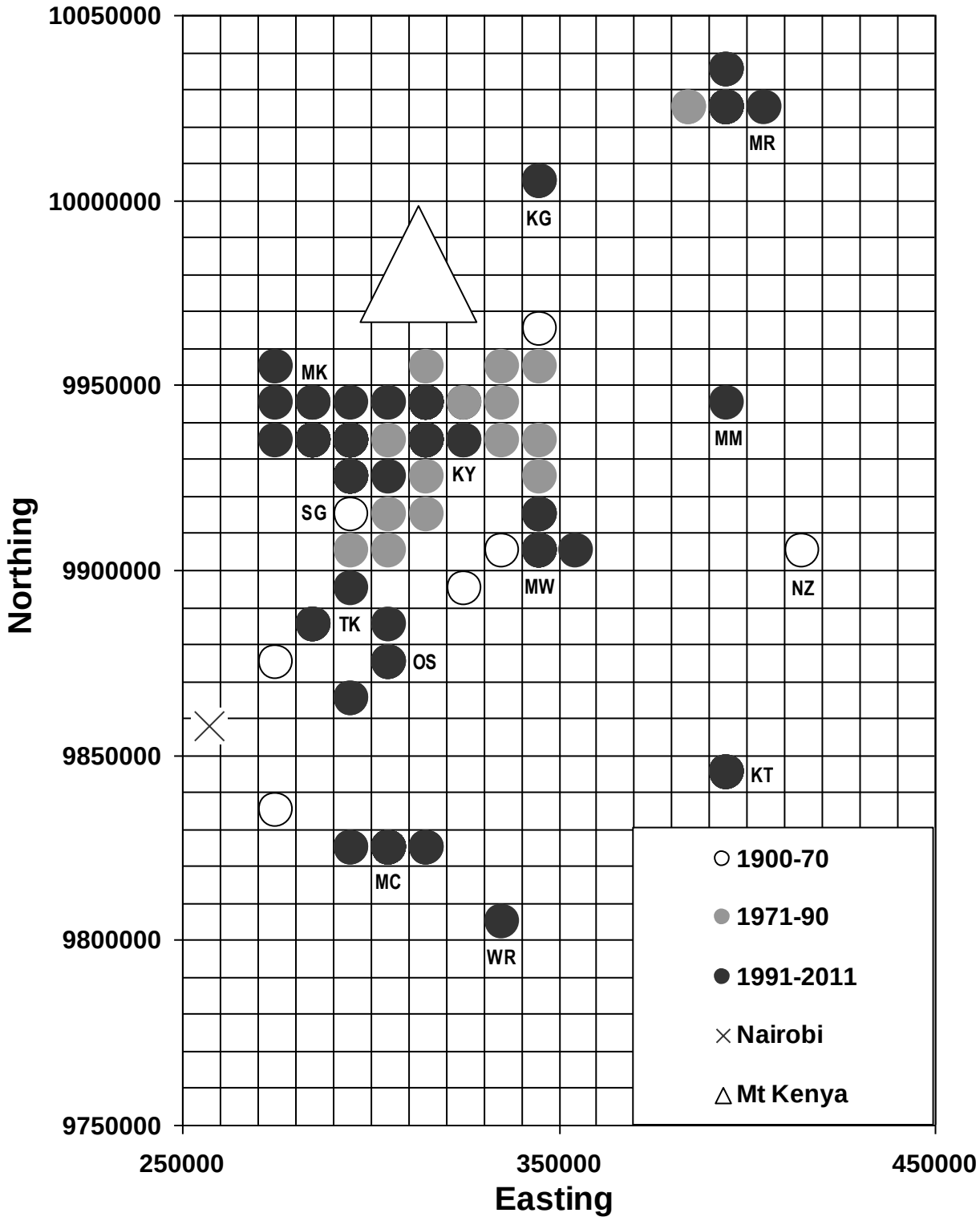
Table 2. Linear regression coefficients relating change in percentage scrub to change in the number of Hinde's Babbler groups, adults and offspring recorded within 1-km sections of transect.

Sites	Measure	R	P	Slope (±1SE)	Intercept	Corresponding change in scrub cover[1]
Kianyaga & Mukurweini	Groups	0.250	0.072	0.046 (±0.0247)	-0.0001	±22.1
	Adults	0.264	0.056	0.167 (±0.0853)	0.0042	±6.0
	Offspring	0.241	0.082	0.052 (±0.0292)	-0.0032	±19.2
Machakos	Groups	0.413	0.063	0.017 (±0.0085)	-0.0001	±59.5
	Adults	0.432	0.051	0.067 (±0.0321)	-0.0008	±14.9
	Offspring	0.336	0.137	0.021 (±0.0132)	-0.0003	±48.7

[1]Change in scrub cover (expressed in percentage points) associated with the gain or loss of one Hinde's Babbler group or individual

List of Figures

Fig. 1.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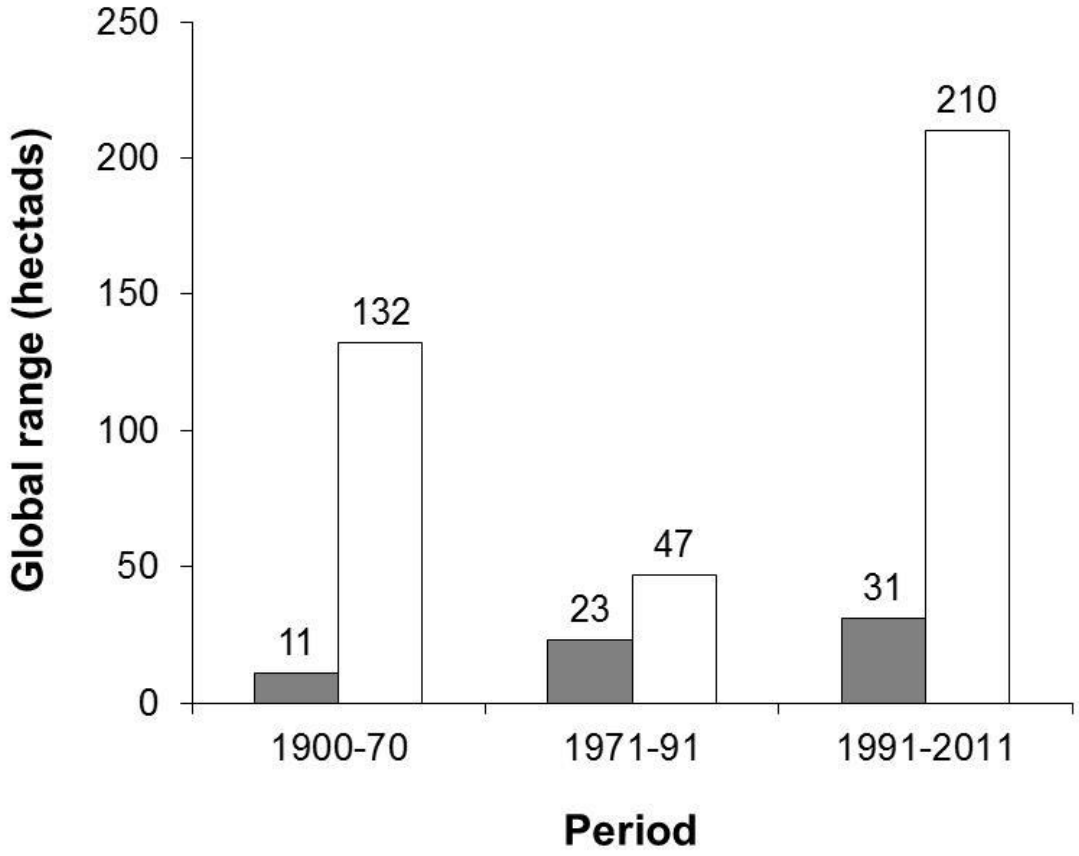
MK
MM
KY
SG
MW
NZ
TK
OS
KT
MC
WR
1900-70
1971-90
1991-2011
Nairobi
Mt Kenya

Fig. 2.


Global range (hectads)
250
200
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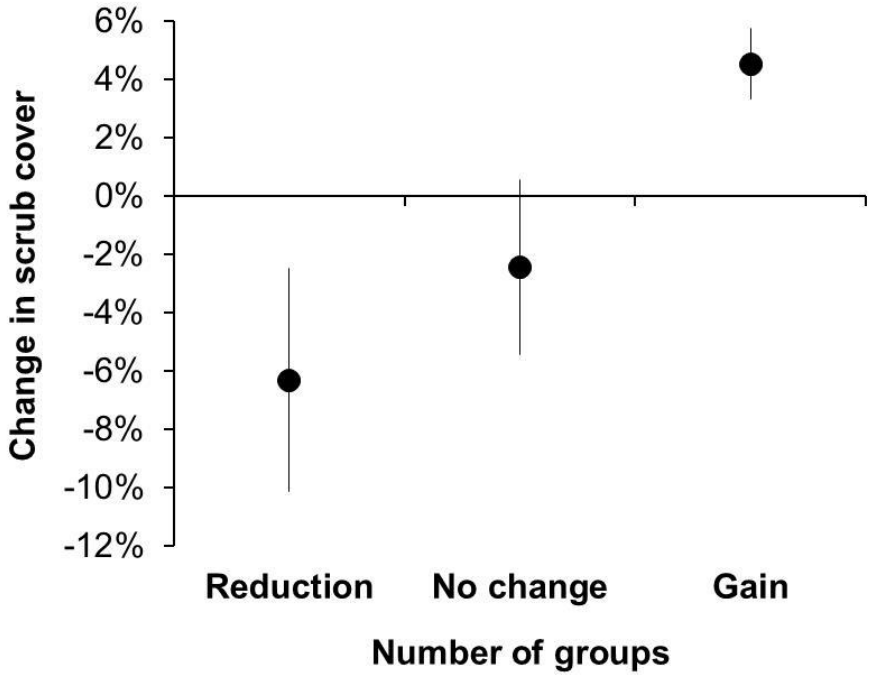
0
132
210
47
11
23
31
1900-70
1971-91
1991-2011
Period

Fig. 3.

A.


6%
4%
2%
0%
-2%
-4%
-6%
-8%
-10%
-12%
Change in scrub cover
Reduction
No change
Gain
Number of groups

B.

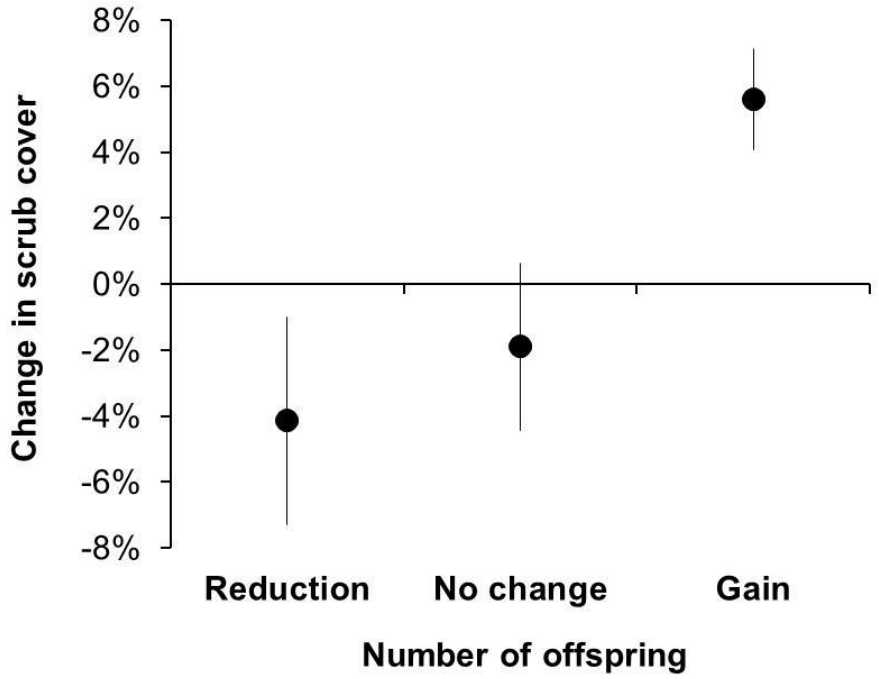
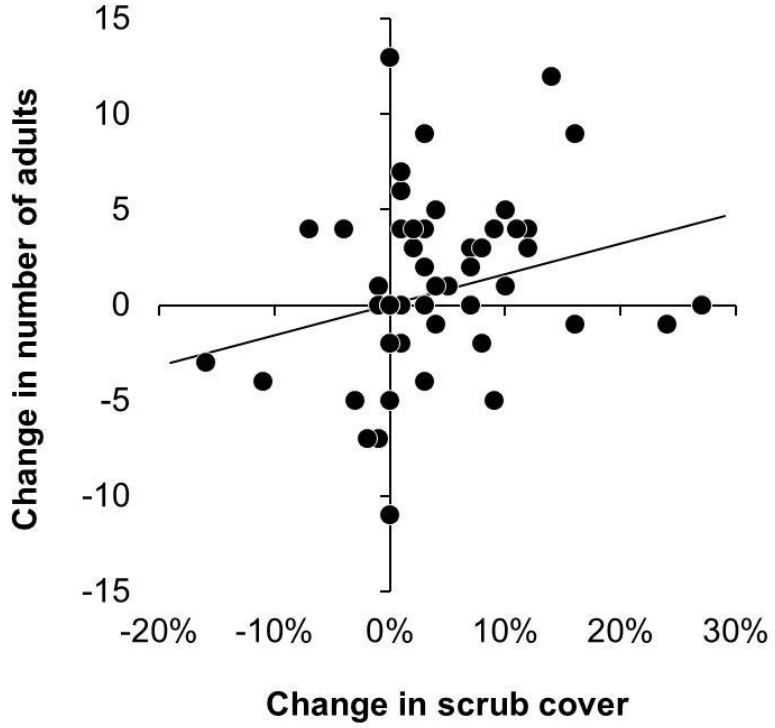
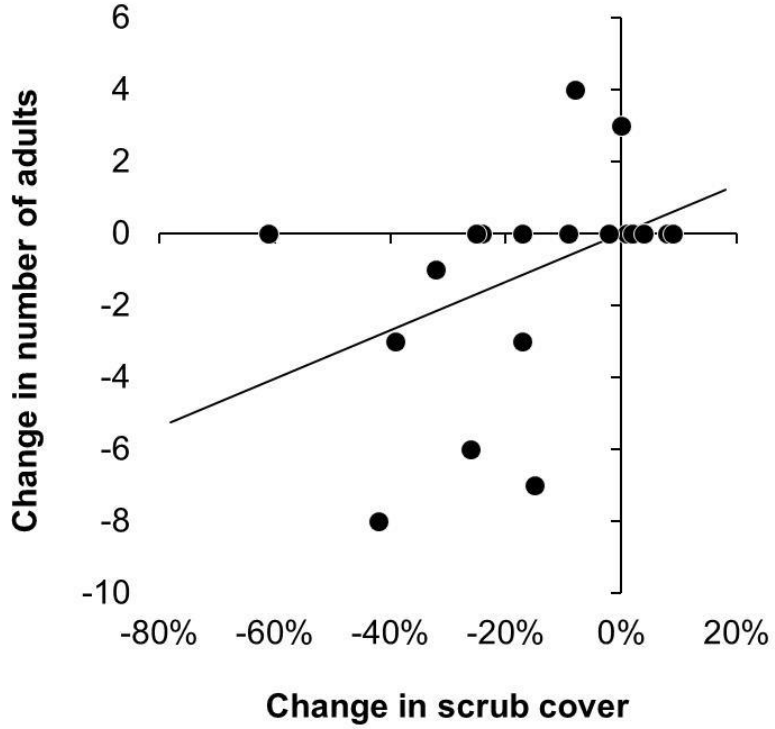

8%
6%
4%
2%
0%
-2%
-4%
-6%
-8%
Change in scrub cover
Reduction
No change
Gain
Number of offspring

Fig. 4.

A.


15
10
5
0
-5
-10
-15
-20%
-10%
0%
10%
20%
30%
Change in number of adults
Change in scrub cover

B.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4
2
0
-2
-4
-6
-8
-10
-80%
-60%
-40%
-20%
0%
20%
Change in number of adults
Change in scrub cover